Electronic distance metre featuring spectral and spatial selectivity

5   The invention relates to an electronic distance meter featuring spectral and spatial selectivity according to the pre-characterizing clause of Claim 1.

In many applications of distance measurement, but
10 especially in the case of LIDAR measurements (Light Detecting and Ranging), a useful signal of the distance measurement must be obtained from a radiation background. The intensity thereof may be several times above the intensities of the useful signal. However,
15 owing to its properties, this useful signal can be separated from the background by means of spectral or spatial filters. In general, the measured signal is emitted parallel to or coaxially with the axis of the transmitter, so that the signal is reflected back in
20 the direction of the axis of the transmitter by the generally diffuse surface to be surveyed. Moreover, the spectral range of the emitted light can be chosen so that the broadband background radiation can be separated off by spectrally selective reflection or
25 absorption.

A typical field of use of such distance metres for air- or space-supported applications with LIDAR systems, in which distance measurement to objects or surfaces is
30 effected exclusively or simultaneously with the recording of further parameters and in which a high proportion of foreign or interfering radiation is received.

Here, systems which are used on board aircraft or spacecraft have to meet particular requirements since there are generally strict weight restrictions. Moreover, problems occur in the case of space-supported use owing to the high received radiation intensities and the associated thermal load, for example due to direct sunlight or due to the radiation of hot surfaces themselves, such as, for example, fires or metallic melts. Thus, a satellite which scans the topography of a celestial body with LIDAR from a circumpolar orbit should in principle be capable of handling the different boundary conditions of the day and night side of a planet. The day side gives an extreme proportion of background radiation from which the LIDAR signal to be used has to be obtained. However, similar difficulties can also occur in the case of earth- or air-supported applications over a strongly radiating or reflecting surface, such as, for example, ice, water or desert sand.

For suppressing or screening the background radiation, a multi-stage filtration concept with spectral broadband, narrowband or local or spatial filters is used.

The spectrally broad fraction of the filters has two separate filters reflecting in the ultraviolet (UV) and in the infrared (IR) range.

The UV filter component consists of a dielectric multi-layer coating on that side of the instrument aperture which faces the outside. The filter component can, for

example, be mounted as a layer on a ZnSe plate in the aperture, wavelengths below 600 nm being reflected without absorption but longer wavelengths being transmitted without absorption. Such filters are very complex but can be technically realized by limitation to a spectral range.

The IR filter component is located downstream of the UV filter component and has a gold mirror which does not absorb for this wavelength band. The ZnSe carrier material of the UV filter component in turn ensures absorption-free radiation transport between the two mirrors.

The spatial filter component is provided by direct or indirect focussing of the radiation onto the sensor used for reception, the sensor surface acting as a field stop. However, the stop effect can also be supplemented or replaced by a fibre located upstream of the sensor. In the case of a perpendicular system, i.e. a system viewing in the nadir orientation on to the surface, the relevant radiation is incident at zero degrees. For focusing, that side of the ZnSe plate which faces away from the outside can be suitably formed, for example as an individual lens or as a lens arrangement. The gold layer of the IR filter component is then arranged in or close to the focal plane of the lens so that, in cooperation, any radiation incident outside the nadir direction is reflected.

The spectrally narrowband filter component is compact, for example in the form of a Fabry-Perot interferometer or fibre grating, having a bandwidth of < 1 nm about

the LIDAR wavelength, so that any radiation outside this range is suppressed in the nadir direction.

By the multi-stage selection of the incident radiation, the useful radiation of the LIDAR system can be separated from the background radiation, heating of the arrangement being avoided by reflection. Particularly in the case of satellites, this "thermal load" is a critical parameter which has to be minimized since the necessary cooling power has to be taken from the energy supply present. Thus, recordings can also be carried out from strongly emitting surfaces, such as, for example, the day side of a planet close to the sun, in particular without special cooling devices, which leads to mass reductions of about 1.3 kg.

At the same time, the arrangement permits a particularly compact structure which, for example, also allows two-dimensional arrangements. Thus, the inside of the ZnSe plate may be in the form of a 10 x 10 multi-lens arrangement (lenslet array), so that a short focal distance and hence a short design can be achieved with the same numerical aperture. The lenses can guide the received radiation into the entry orifice of a downstream fibre, these fibres being led either to a separate detector each or to a common detector. The narrowband filter component can be arranged between fibre end and detector. The connection and mechanical fixing of a lens arrangement and fibres can be realised by a hexagonal, honeycomb-like beryllium structure so that strong structures are ensured in combination with low weight.

By assigning individual fibres to a separate detector each, the system redundancy on the detector side can be increased and even formed for the detection of individual photons, without major hardware modifications being necessary.

However, a remaining disadvantage is the spatial division of transmitter and receiver component. Although a compact design is in principle realisable by the possible embodiment described, separate transmitters and receivers nevertheless have a different beam path and an offset of their axes. Moreover, different types of components have to be integrated into one arrangement, which leads to greater technical complexity and increased outlay in manufacture. In addition, owing to the available area, the powers of transmitter and receiver are limited since an increase in the number or area of transmitter apertures reduces that of the receiver apertures.

The object of the invention is to provide a distance meter, in particular for telescope systems, which is simplified in construction.

A further object is the provision of a distance meter having improved utilisation of the available space, area and weight limits.

These objects are achieved, according to the invention, by the subjects of Claim 1 or of the dependent Claims or the achievements are further developed.

The invention relates to an electronic distance meter having spectral and spatial selectivity, in particular for telescope arrangements for earth- or space- supported applications.

According to the invention, the fibre arranged downstream of the spectrally broadband filter components is formed by a fibre laser which is used as a common component for transmitter and receiver. Here, light is produced by a pump laser and is input into one of the end faces of the fibre laser. The laser emission produced is used for surveying and on reception, after passing through the broadband filter components, is input back into the fibre laser, but now from the other end face, and is guided by said fibre laser. Since pump light and laser light have different spectral ranges the two components can be separated from one another. In addition, it is possible to introduce time discrimination, which takes into account the time delay due to the finite transit time of the laser signal there and back. After leaving the fibre laser, the reflected light is guided via the narrowband filter component on to the sensor.

Further details of the invention and various embodiments are shown schematically and by way of example in the drawings. Specifically,

Fig. 1   shows the schematic diagram of the effect of the broadband filter components;

Fig. 2   shows the schematic diagram of the cooperation of the various components;

Fig. 3 shows the schematic diagram of a first
embodiment according to the invention and

Fig. 4 shows the schematic diagram of the relationship
between arrangements for realising a second
embodiment according to the invention.

In Fig. 1, the effect of the broadband filter
components is explained schematically. Radiation S
incident at different angles strikes the UV filter
component 1 as a second spectral filter component which
reflects the UV component UV of the incident radiation
S. The remainder is fed via a ZnSe plate 2 which has a
shaped lens structure 2a. The lens 2a carries an anti-
reflection coating 3 for improving the transmission of
radiation reflected back.   By means of this
arrangement, the infrared component IR of the radiation
is also transmitted but, after passing through an IR
filter component 4 as a first spectral filter
component, is reflected back so that, after passing
again through the ZnSe plate 2 and the UV filter
component 1, the IR component IR leaves the distance
metre again.

Fig. 2 shows the schematic diagram of the cooperation
of the various further components. After the first
filtration explained in Fig. 1, the remaining radiation
strikes the spatial filter component 6, which is in the
form of a fibre here. This effect can equally also be
achieved by a stop or the limitation of a sensor area.
The IR filter component 4 is displaced into the focus
or fibre entrance, the diagram chosen here being purely

schematic and in particular the size relationships of
fibre and IR filter component 4 being not represented
exactly.   Any radiation incident outside the nadir
direction is reflected by this arrangement.   After the
5   selection of direction by the spatial filter component
6,   a   further   selection   step   is   effected   by   the
narrowband   filter   component   7   as   a   third   spectral
filter   component,   which   may,   for   example,   be   in   the
form   of   Fabry-Perot   interferometer   or   reflecting
10   grating   structure.   By   the   cooperation   of   the
components,   the   incident   radiation   S   is   separated   with
respect   to   its   spectral   and   direction   components,   a
major   part   of   the   radiation   being   reflected   in   order   to
avoid   or   at   least   to   reduce   heating-up   of   the   distance
15   metre.   For   simplification,   further   components   of   the
beam   path,   such   as,   for   example,   lenses,   are   omitted   in
this   diagram.

Fig.   3   describes   the   schematic   diagram   of   a   first
20   embodiment   according   to   the   invention,   with   the   filter
steps   shown   in   Fig.   1   and   Fig.   2.   Incident   radiation   S
is   fed   via   the   UV   filter   component   1,   ZnSe   plate   2   with
the   lens   structure   2a   and   the   IR   filter   component   4.
After   passing   through   this   IR   filter   component   4,   the
25   radiation   is   input   either   into   the   multimodal   part   of
the   fibre   (case   A)   or   via   a   microlens   5   into   the   active
fibre   core   6a   for   postamplification   of   intensity   (case
B).   In   the   former   case,   that   end   of   the   fibre   which   is
located   on   the   detector   side   must   be   provided   with   an
30   intensity   stop   6b,   but   with   a   fast   switch   in   case   B,
for   example   in   the   form   of   a   Q-switch.   In   case   B   a
time-related   separation   of   emission   of   the   fibre   laser
and   switching   through   to   the   sensor   11   is   then

effected, so that the fibre core 6a acts as a postamplifier when the switch is open. Both fibre regions additionally act as spatial filters. The filter laser has, for example, an active fibre core 6a having a diameter of 4 microns, the multimodal structure having a diameter of about 100 microns. In the multimodal structure, the received radiation S is passed through the fibre laser and finally passed via a first lens 8a, a dichroic beam splitter 10, the narrowband filter component 7 and a second lens 8b onto the sensor 11. Parallel to this received beam path, however, the arrangement is also used, according to the invention, for emission of the measuring radiation ES used for the measurement. For the production thereof, a pump light source 9 emits light which is collimated by a third lens 8c and input via the beam splitter 10 and the first lens 8a into the fibre laser. For avoiding adverse affects of the laser emission of the fibre laser on the components of the receiver, in particular on the sensor 11, the fibre laser has, on the receiver side, an end element 6b which optically covers the active fibre core 6a. The measuring radiation ES produced by the fibre laser is brought, via a telescope arrangement comprising microlens 5 and lens structure 2a, into the beam profile desired for the emission. The optical fibre is thus operated in a forward mode of operation as a fibre laser in the emission mode, whereas, in a backward mode of operation, the fibre serves as spatial filter component 6' of the receiver. By means of this dual use, emission and detection are implemented by means of the same substantially optical components, resulting in a design simplification which has advantages with regard

to space and weight restrictions.

A combination of a plurality of fibres to give a second
embodiment according to the invention is shown in Fig.
4. The relationship between arrangements of the fibres
for realising a second embodiment according to the
invention is shown purely schematically. The ZnSe
plate 2' now has a plurality of lens structures 2a' as
a multilens array, with each of which a fibre is
coordinated as spatial filter component 6'. The IR
filter component 4 is mounted between the respective
lens structure 2a' and the coordinated fibre entry.
Said IR filter components can be formed as a continuous
structure but also for each fibre separately. For
simplifying the diagram, further components, such as,
for example, microlenses, are not shown. Measuring
radiation ES is produced by each fibre as a fibre laser
and is emitted in turn by means of the coordinated lens
structure 2a'.

Thus, the components located downstream of the fibres
can likewise be formed or used for each fibre
separately or for all fibres or a plurality of fibres
together. Thus, an individual sensor can be
coordinated with one fibre in each case.
Alternatively, however, radiation of a plurality of
fibres can also be fed to a common sensor. Likewise, a
plurality of fibres can be pumped from a common light
source or, as shown in Fig. 3, can have a separate pump
light source.

By forming each fibre as a receiver and transmitter,
standardization of the various apertures in an

arrangement can be achieved, so that both manufacturing and operational advantages, such as, for example, coaxial arrangement of transmitter and receiver, follow, but optimized use of the available space or of the area and of the weight can also be achieved.